BELL TELEPHONE MAGAZINE

VOL. XX MAY, 1941 NO. 2

ENGINES FOR DEFENSE

A COLLEGE COURSE IN TELEPHONE SPEECH

INDEPENDENT TELEPHONE COMPANIES

TRENDS IN TOLL CABLE USAGE

CHEMISTRY BEHIND THE TELEPHONE

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BELL TELEPHONE MAGAZINE

Continuing the BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

VOL. XX MAY, 1941 NO. 2

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A BELL SYSTEM TOLL ROUTE

Along this cross-country right of way the newer aerial cable (foreground) supplements the open-wire line, which is still in service. Other types of cable are laid under ground. *See "Trends in Toll Cable Usage," beginning on page 97*

ENGINES FOR DEFENSE

The Danger of Interruptions to Telephone Service Is Further Guarded Against by Numerous Installations of Emergency Power Equipment for Charging Central Office Batteries

By FRED K. ROWE

In a recent mystery novel, two of the characters, discussing the effects of power interruption on the life of a great city, have the following conversation:—

"'What about the telephone? I suppose it would go too?' The other shook his head. 'That's one of the companies which have had enough foresight to prepare for emergencies. They have a secret power plant of Diesel engines safely hidden away.'"

The book is fiction, but the statement—except for the reference to secrecy—is essentially a fact.

In the report of the American Telephone and Telegraph Company for 1940, President Gifford made the following announcement: "Reserve power equipment was installed or ordered at all important telephone central offices which did not already have it, so as to insure continuity of power supply under all conditions."

Further reference to this increased provision of emergency engine equipment was made in the article "The Bell System and National Defense" which appeared in the February, 1941, issue of this magazine; and a recent article in a trade magazine, commenting on the increased use of engine-driven equipment for emergency sources of power, remarked that "The A. T. & T. Company realizes the likelihood of interruptions so we are seeing scores of emergency Diesel plants being installed by the Bell Telephone System."

What is the emergency equipment that is thus referred to? Briefly, it consists of an engine driving a generator for furnishing power to keep the batteries in the central office charged during an interruption of the commercial power service. Should these batteries be allowed to become discharged, the office could not function, and, while a failure of a telephone office even under normal conditions might be termed a calamity, it takes no great effort to realize the vital importance as a defense measure of making sure that under no condition will there be an interruption of the current required to keep the storage batteries in telephone central offices in a properly charged condition.

Experience has indicated that under normal conditions the large ma-

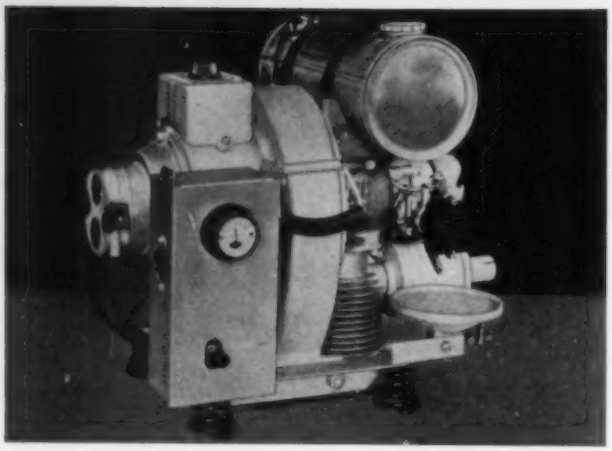


FIG. 1. A 650-WATT PORTABLE GASOLINE EMERGENCY SET

One of these may serve as a source of emergency power for several closely grouped dial or manual central offices

jority of power failures are of short duration and do not approach the period during which the batteries will continue to carry the office load before they become discharged. Telephone service, however, must be maintained under abnormal as well as normal conditions, and it is these abnormal conditions which determine the need for providing emergency engine equipment. Such abnormal conditions arose, for example, during the unprecedented floods of 1936 and 1937 which made it impossible for days to supply electric power service to such cities as Pittsburgh, Hartford, and Louisville.

For another illustration, there was the short circuit and fire in the Hell Gate power station in January, 1936, which interrupted power in a large part of New York City for several hours. A fire in the Essex power station in December, 1936, resulted in power failure in the central part of Newark, New Jersey, and in some suburbs, for intervals of from five to eight hours. The March, 1938, floods in Southern California, reported to have been the worst in 61 years, resulted in prolonged failures of electric power service in many localities. During the New England hurricane of September, 1938, entire communities were out of power for periods up to three weeks, due to devastation of power lines and crippling of power stations.

EXCEPT for a few relatively unimportant and isolated cases, none of these emergencies in the past has resulted in a failure of the central office batteries to continue to carry the load. In instances, however, where no emergency engine equipment was installed, it was necessary to make hurried arrangements for procuring it. This is never a simple task, in view both of the time elements involved and of the demand for similar equipment by others, such as hospitals, whose service also needs protection. Even after locating suitable equipment, such as arc welding sets from local sources and battery charging sets from other telephone companies, there is always a serious transportation problem in the case of large charging sets coming from a distance. Many of these have been sent hundreds of miles—for example, from Milwaukee to Pittsburgh by truck during the dead of winter over ice-bound roads.

There then follows the task of setting up and connecting the sets to the load and of providing suitable shelters. No provision is normally made for the storage of gasoline supplies, and obviously considerable trouble would be experienced in obtaining fuel because gasoline filling stations are almost universally equipped with electrically driven pumps and naturally are inoperative when power lines are not functioning. Because of prompt, skilful and efficient action, there has been no failure of telephone service due to depleted batteries, but there have been many anxious moments for fear that the needed equip-

ment might not be obtained in time to prevent the batteries from being discharged. Another reason for anxiety is that such emergencies require an extraordinary amount of time and effort that are always needed for other work.

Adequate Provision for Emergencies

As a consequence of such experiences in the past, and because national defense requires a telephone service without threat of interruption, the Bell System operating companies have reached the conclusion that adequate provision be made now so that all offices may be readily operated when necessary from emergency sources of power.

Of the 5,200 offices having storage batteries, there are about 4,000 which are of such a size that the batteries can economically be made large enough (generally from one to three days' capacity) so that the office load may be carried on the battery until a small portable engine driven charging set, such as shown in Figure 1, can be brought in and placed in operation to pick up the load. Such a set is small, the one pictured weighing only 71 pounds, so that in general one man can quickly load it into a truck, transport it to the office, and connect it to the battery. Some 200 sets of this general type, ranging in size from 650 to 3,000 watts, are distributed throughout the System, and while this number has so far proven adequate, more than 300 additional sets are being purchased.

The 4,000 offices just mentioned

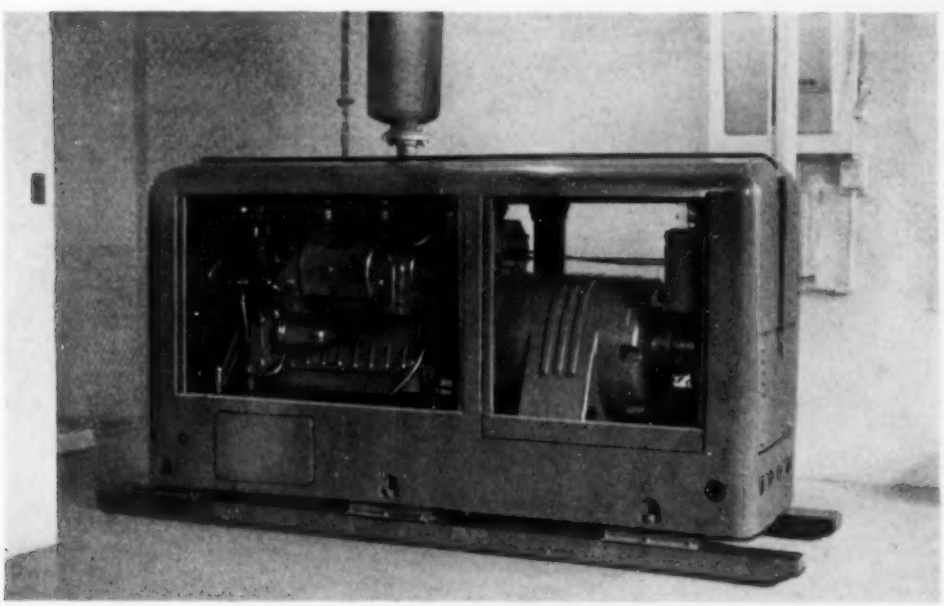


FIG. 2. A 60-KILOWATT STATIONARY DIESEL EMERGENCY SET

A set of this size may be installed to serve two and sometimes three small dial units, and may be used temporarily as a portable set in an emergency

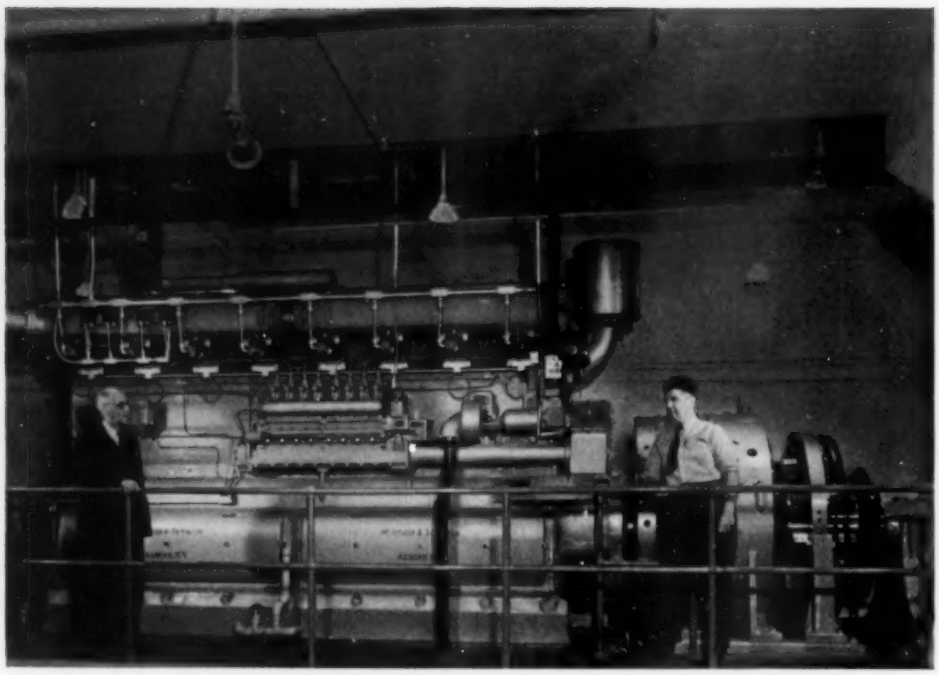


FIG. 3. A 535-KILOWATT STATIONARY DIESEL EMERGENCY SET

Including engine, generator, and concrete base, it weighs nearly 100 tons, and has sufficient capacity to supply power to five large dial units and, in addition, to care for essential building services in an emergency

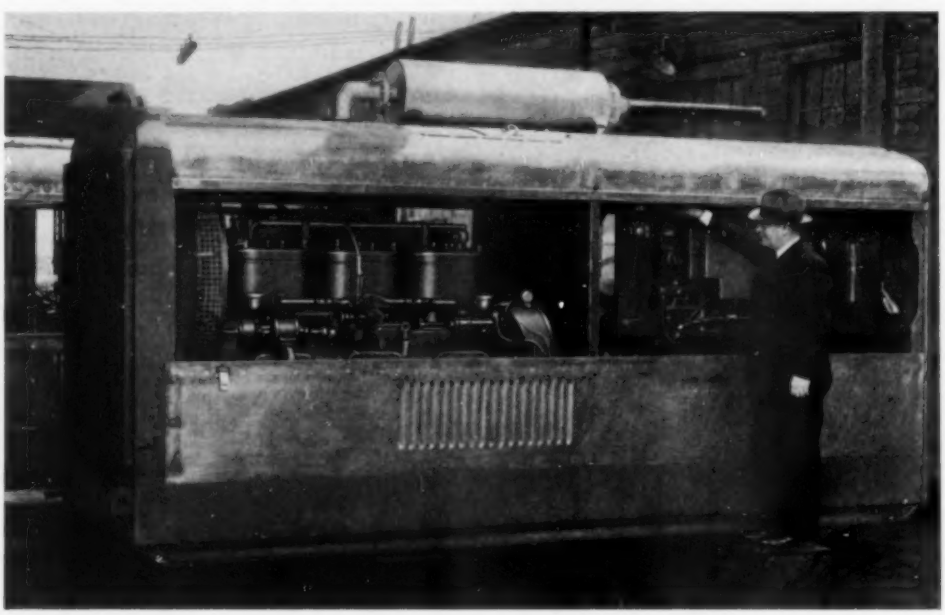


FIG. 4. A 75-KILOWATT PORTABLE GASOLINE EMERGENCY SET

The Bell System now has more than 50 such sources of emergency power, one of which can be trucked in a few hours to any location where it may be needed

consist for the most part of small dial and manual offices and small repeater stations. The remaining 1,200 of the 5,200 common battery offices comprise the larger and more important offices in the System, where it is the general practice to provide not more than two to six hours' reserve in the battery. Of these, 850 are now provided with emergency engine equipment that is permanently installed in the building. The sizes of the units involved range in capacity from about 10 kw to nearly 900 kw, with most of them, however, not exceeding 60 kw. Figure 2 illustrates a typical 60 kw installation, while Figure 3 is typical of the very large units, the one shown being rated at 535 kw. These very large units are all located in large buildings and it has been the general practice to provide them with sufficient capacity to care for limited elevator service, other essential building services such as fire and sump pumps, lighting in operating rooms and test centers, as well as the usual telephone load.

THERE remain about 350 large offices which have been served by two or more independent power services and in which emergency engine equipment has not as yet been installed, but it is expected that the program under way towards providing this equipment will have been largely completed within the next year. For use pending the completion of this program, the System has over 50 large portable engine generator sets in case the commercial power service should be interrupted at any of these offices. Figure 4 illustrates one of the large portable sets. A recent situation in one of the large central western cities threatened to interrupt the electric service, and several of these sets were brought in from other cities as far as 500 miles away.

Automatic Power Supply for Unattended Stations

IN connection with the recent installation of carrier systems on transcontinental routes, it has been found necessary to locate some repeater stations at points which are inaccessible, particularly during the winter season. If storm damage should cripple the power lines supplying these stations, and cause a power failure, the work of restoration would be retarded or hampered in some cases by difficulties of the terrain. Although the storage batteries at these stations are usually large enough to carry the load for one or two days, it is considered undesirable under these conditions for repeater stations to depend on portable sets. Moreover, since they are normally unattended, so that no one is present who could start an engine, it has been necessary to provide engine sets that will start automatically in case of accidents to the electric service. Figure 5 shows one of these sets, which will start to charge the battery when the battery voltage drops to a certain value and will stop when the battery reaches full charge. This cycle, of course, will be repeated if necessary as long as the usual supply of power is unavailable.

THE engines associated with the emergency equipment are in general designed for operation on either gasoline or fuel oil, and are cooled by a radiator and fan, as in the case of an

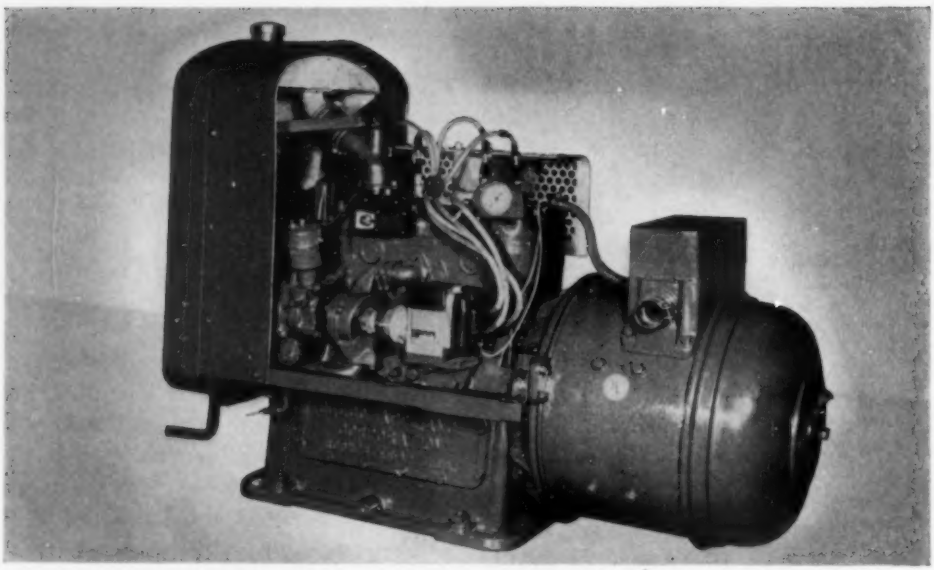


FIG. 5. A 6-KILOWATT AUTOMATIC GASOLINE EMERGENCY SET

Automatic control equipment starts this engine when the battery voltage drops to a predetermined value, and stops it when the battery reaches full charge. The cycle will repeat, without attention, as long as normal power supply is cut off

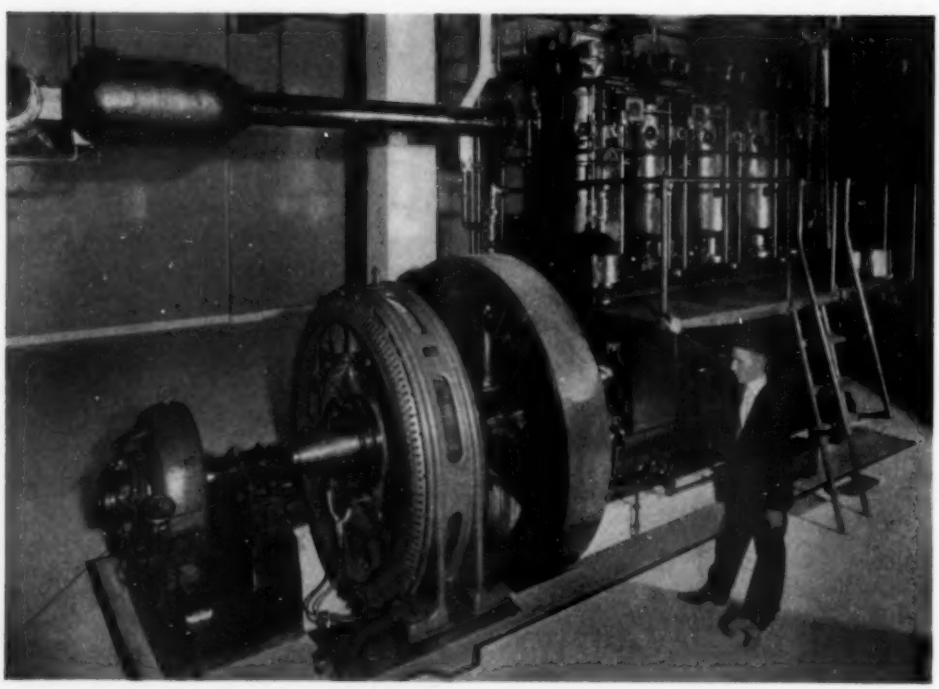


FIG. 6. A 120-KILOWATT GAS EMERGENCY ENGINE OF 20 YEARS AGO

Compare this set with the one shown in Figure 3, which is about the same size as this but has nearly five times the capacity

automobile engine. Some of the early Bell System installations, however, utilize gas as fuel and are cooled by city running water. In order that these engines may be independent of all supply services that might be interrupted in times of emergency, consideration is now being given to a program of arranging them for operation on gasoline, with radiator cooling. The student of engine design will be interested in comparing Figure 6, which illustrates one of the older gas engine sets installed about 20 years ago, with Figure 3, which shows an engine of about the same size but having five times the capacity.

AND so, if and when the continued functioning of the central office batteries giving electrical life to telephone facilities is threatened, there will be means readily at hand with which to meet the emergency. To those entrusted with the responsibility of rendering a telephone service "free from . . . delays" this is a reassuring situation.

A COLLEGE COURSE IN TELEPHONE SPEECH

Classes in Public Speaking for Seniors at Rutgers University Now Include Instruction in Extending the Voice and Personality Pleasingly and Effectively by Telephone

By FRANK P. TOWNSEND

Now comes a college course in practical telephone speech, to serve as encouragement to telephone people who for years have been striving in a variety of ways to increase public interest in "good telephone usage."

A four-week course of telephone speech instruction was introduced in April, 1941, as a permanent part of senior year courses in public speaking and debate at Rutgers University, New Brunswick, New Jersey. It is believed to be the first course of its kind in the country, and the fact that it makes use of the "hear your own voice" technique is of special interest in view of production by Western Electric Company of the "Mirrophone" magnetic tape recorder for public exhibition and instruction.

Announcement of the introduction of the course produced considerable publicity in newspapers and in publications circulating among members of college faculties, suggesting an increasing consciousness of the importance of proper use of the telephone, particularly in the business world.

Richard C. Reager, Associate Professor of Public Speaking and Director of Speech and Debate at Rutgers, is responsible for the new course. He is co-author of the text book "Speech Is Easy," Rutgers University Press 1938, which is regarded as one of the most practical volumes on speech instruction.

In common with many colleges and schools, Rutgers has provided instruction in public speaking and debate for a lengthy period. In recent years the use of microphone and loudspeaker has been added to older forms of instruction to help students familiarize themselves with the advantages and restrictions of public address systems, now in common use.

Class room procedure was recently modified successfully by making recordings of students' voices. A student addresses the class. His remarks are heard by loudspeaker, and part is recorded. He then joins the class and hears the record played, taking part in comment and criticism.

"We were immediately convinced of the effectiveness of the 'hear your own voice' technique," Professor Reager states. "For some twenty years I have been speaking at conventions and to groups of business men on the

LISTENING TO A RECORDED CONVERSATION

The two students who conversed by telephone, out of hearing of the class, have rejoined the group, and all are listening not only to what they said but to how they said it. Professor Richard C. Reager is at the extreme right

subject of better speech as an aid to the business man. I have had occasion to mimic some of the common speech faults, and invariably I sense a reaction among my auditors to the effect that 'Of course, *I* never make such mistakes.' Recordings in the class room, where the student hears his voice, thoroughly upset this happy belief! Improvement is rapid, however, as soon as 'mike fright' disappears. Early records are kept for comparison with recordings made toward the end of the course. Thus the student can note his progress.

"In my opinion a great deal of nonsense is taught and written about speech. At Rutgers we approach the subject from a strictly practical viewpoint. We are turning out young men, many of whom will go into business. Good speech is one of the most helpful assets these men can have, especially since their careers are still ahead. Therefore, we are interested only in speech that can be used intelligently. *Speech to be useful and valuable must be practical!*

"It occurred to us that for every occasion when a man speaks from the platform or in the conference room, he takes part in hundreds of telephone conversations. Again, this applies particularly to the younger men. So far as we knew, no school or college offered instruction in use of the telephone—not even schools specializing in speech training. Yet your voice, by telephone, is often your first introduction to some stranger. His first impressions are likely to be determined by how you sound to him in his receiver. No matter what you actually may be like, if you *sound* ill-educated,

RECORDING A CONVERSATION

Two Rutgers seniors converse and Professor Reager monitors as the apparatus in the center makes a record of the conversation. Specially grouped for this picture, the students are actually stationed in separate rooms for regular instruction

slovenly, or uninterested in the other man's affairs, his impression will be unfavorable. Regardless of the logic of it, decisions are made every day (and often important decisions) on nothing more tangible than the thought: 'He seems like a pleasant chap,' or 'I didn't like him!' This led us to believe that instruction in speech for practical daily use is incomplete without training future business men to extend their voices and personalities by telephone in an effective, pleasant manner."

Recording Permits Review

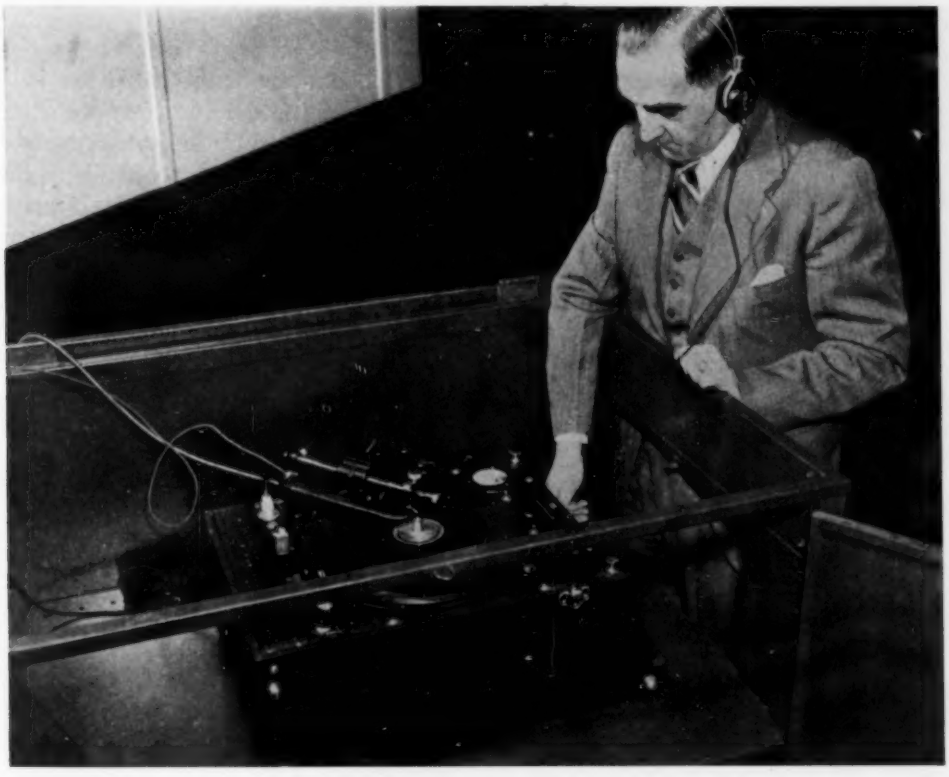
WHEN the new four-week course was introduced, use was made of the recording technique because of its effectiveness in public speech instruction. Two students go to separate telephones which are connected to the equipment. They converse on various topics, such as a detailed business transaction, a campus problem, or perhaps arrange an interview. Their remarks are heard in the class room by loudspeaker, and part is recorded. Then the participants join the class and hear the recordings for comment and criticism.

The equipment used was assembled by Walter K. Dau, Jr., a Junior in Rutgers School of Engineering. It consists of a portable recorder with loudspeaker, and a plug-in microphone for use during public speaking instruction. For recording telephone conversations, the telephones mentioned above may be connected with

this equipment. Recording is monitored by headphone. The apparatus is contained in a locking steel cabinet, mounted on rubber-tired wheels, which also serves as storage space for auxiliary equipment, replacement parts and new and used records.

Preliminary experiments made use of non-working telephones, students "conversing" with each other in the class room. Moderate progress was achieved. However, as soon as recordings were introduced there was a marked improvement. Students were in agreement that the "hear your own voice" method provides a "vivid and very personal *feeling*" as to how they sound by telephone.

Even students who had achieved some proficiency in platform delivery discovered immediately that quite different methods are necessary for best results during telephone conversations. It is not only that voices sound changed. On the platform, a speaker can use facial expression, gestures, and even the fact of his physical presence to offset or minimize effects of faulty speech. By telephone, the voice carries the entire burden. It becomes necessary, they learned, to concentrate on what comes out of the dis-



THE RECORDING INSTRUMENT

Professor Reager adjusts the input of the recorder as students in distant rooms carry on a telephone conversation

tant telephone receiver, and then to adjust voice and manner at the transmitter to obtain the desired effect.

The essentials of good public speaking apply, in general, to telephone speech and its instruction. These include proper use of the vocal mechanism, clarity, prior knowledge if possible of what is to be said, conversation along orderly and logically developed lines, care in producing and maintaining a courteous and friendly effect on the hearer, good vocabulary, unhurried manner. The New York Telephone Company's booklet, "The Voice With a Smile," which was drawn upon freely in preparation of the telephone chapter in Professor Reager's text book, "Speech Is Easy," also serves as background material for class room instruction in telephone usage.

Better Speech—Better Service

THE interest of telephone people in "good usage" is based in part on the philosophy that telephone service, regardless of technical excellence, should not be considered as entirely satisfactory unless it is so regarded by the customer. A number of telephone developments resulting from this viewpoint will come to mind, such as operating practices and methods which have been devised not merely to avoid the possibility of confusing customers but to be actually pleasing to them.

A further extension of this thought is the acceptance by telephone companies of responsibility for assisting customers to obtain the most usefulness and value from their service. Efforts are increasingly being made to help eliminate slovenly speech habits and faulty technique, and overcome unconscious mannerisms which may give the effect of discourtesy or inattention at the other end of the line. Booklets are distributed giving practical suggestions, based on experience and observation, for improved usage in business concerns. Some telephone companies maintain a staff of employees to train telephone contact people in business establishments.

These are considered service improvement activities, since anything done by the telephone company which assists a customer to handle his affairs by telephone more efficiently, pleasingly, or satisfactorily is a service improvement to him, just as are better transmission or faster handling of calls.

FOR some time there has been evidence that these efforts are bearing fruit in increased public consciousness of the importance of good telephone speech. More and more requests come to telephone companies for assistance in training telephone sales forces and other telephone contact employees. The "Hear Your Own Voice" magnetic tape recorders demonstrated in the Bell System exhibits at the New York and San Francisco World's Fairs in 1939 and 1940, and by many Bell companies during "Open House" programs, made thousands of individuals conscious of speech defects of which they had been unaware. The System's sound motion picture, "A New Voice for Mr. X," which portrays the business value of good telephone speech and practice, has made a strong impression upon business men. This impression has been strengthened when the showing of the film is accompanied by setting up the magnetic tape recorder for the audience to experi-

ment with. Instead of resenting criticism or disbelieving it, they appreciate knowledge of faulty usage *when gained by themselves* through hearing their own voices.

Professor Reager's innovation at Rutgers well illustrates this increased public interest, and is perhaps the most significant illustration to date. So far as is known, it is the first organized effort on the part of an institution other than telephone companies to teach proper telephone speech technique and to assign to the subject a degree of importance in practical daily life that ranks it with public speaking and debate.

Application of the essentials of good speech to the 80,000,000 telephone calls handled daily in the Bell Telephone System may be too much to hope for within the foreseeable future, but the new course at Rutgers certainly is a step toward such a goal and forecasts the introduction of similar instruction in schools and colleges generally as something not too visionary.

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FIG. 1. EACH DOT REPRESENTS AN INDEPENDENT TELEPHONE COMPANY EXCHANGE

There are 12,000 dots on this map, which was prepared in 1938 by, and is used through the courtesy of, the United States Independent Telephone Association

INDEPENDENT TELEPHONE COMPANIES

Co-operation between These 6,400 Organizations, Serving 20 Per Cent of All Telephones in the Country, and the Bell System Is Vital in Providing a Nation-wide Telephone Service

By H. M. POPE

PEOPLE living in areas served by Bell telephone companies may not have occasion to know that, in addition to the 24 operating companies included in the Bell System, there are some 6,400 other telephone companies whose management and personnel play a most important part in giving the United States what is often termed "the best telephone service in the world."

These companies are independent of the Bell System, except that there is a physical connection of their lines with the lines of the adjacent Bell company in order to bring about a universal telephone service nation-wide in its scope.

Because of this physical connection, these companies are known to Bell System people as "connecting companies." They own and serve about 4,400,000 telephones, or approximately 20 per cent of the more than 22,000,000 telephones in the country; they have 10,000,000 miles of wire; they handle in the neighborhood of 19,000,000 local and toll conversations every day.

That the high standard of telephone service in the United States reflects a high degree of coöperation between the Bell and connecting companies must, of course, be apparent. To it President Gifford of the American Telephone and Telegraph Company paid tribute in his report on the Company's operation for 1940 when he said: "this coöperation is invaluable in marshalling the resources of the entire telephone industry in the interest of national defense."

Without such coöperation, telephones could not be so quickly and readily connected one with another, for obviously there is a most complex operating problem involved in so combining the properties of thousands of companies that anyone anywhere can pick up a telephone and talk to anyone else anywhere else. It is to point out some of the features of this co-operation, which results in a combined network handling about 100,000,000 local and toll conversations a day, that this article has been prepared.

The 6,400 connecting telephone companies are scattered over the entire country, having exchanges in every state except Delaware. A map prepared by the United States Independent Telephone Association in

1938, Figure 1, shows the widespread distribution of 12,000 independent telephone exchanges. In several states the connecting companies serve a larger geographical area than that served by Bell System companies.

CONNECTING companies vary in size from those with only one exchange having not more than 10 telephones to those having more than 100,000 telephones located in a number of exchanges. Some of these companies have their own toll lines connecting several exchanges, while others have no toll lines. There are seven connecting companies having more than 50,000 telephones each, two of which, the Associated Telephone Company, Ltd. (California) and Rochester Telephone Corporation (New York), have more than 100,000 telephones.

Many connecting companies are not financially affiliated with any other company or corporation. Some, however, are members of so-called group companies which own the controlling interests in a number of telephone companies operating in several states. The largest three group companies are General Telephone Corporation, with 532,000 telephones; Telephone Bond and Share Company, with 240,000; and United Utilities Company with 98,000 telephones.

Ohio has a larger number of connecting company telephones than any other state, while Maryland has less than 800. The 10 states having the largest number of connecting company telephones are shown in Figure 2.

It became apparent to the non-Bell telephone companies prior to 1900 that some form of central organization was needed in order to provide assistance in respect of the many difficult problems frequently encountered in furnishing reliable telephone service. As a result, the National Independent Telephone Association was formed, and later a second organization, the Independent Telephone Association of America, came into being. These two associations were merged in 1915 to become the present United States Independent Telephone Association, the by-laws of which state: "The object for which it is formed is to aid the Independent telephone industry and to furnish to its members information and advice upon all subjects relating to telephony; and to authorize its officers or committees to represent the Independent telephone interests before any commission, executive officer, legislative or regulatory body of the United States or any state."

One of the first activities of the United States Independent Telephone Association was to encourage the formation of state associations to work in coöperation with the national body.

State	No. of Connecting Company Telephones As of January 1, 1941
Ohio	322,000
Illinois	312,000
Indiana	278,000
Iowa	247,000
Pennsylvania	223,000
New York	220,000
California	203,000
Missouri	188,000
Wisconsin	170,000
Texas	147,000

FIG. 2

In these ten states there are about 2,310,000 connecting-company telephones

There are now 32 state associations. These provide a clearing house for information of interest to their members through annual meetings, frequent group meetings, through advice on problems of all kinds relating to the industry, and through their relationship with the United States Independent Telephone Association. There have been many evidences of coöperation between the Bell System companies and the connecting telephone companies and their state and national associations. Problems of mutual interest, including those dealing with the interchange of toll messages, frequently are discussed at the state association meetings as well as at meetings of the United States Independent Telephone Association. The national and state associations have been of great value to connecting companies throughout the country.

ANOTHER indication of the important part connecting companies play in the industry is the fact that during 1940 about 94,000,000 interchanged toll messages were originated by customers of connecting companies. The services performed by connecting companies in the handling of so many millions of interchanged toll messages vary considerably, of course. In all cases the connecting company bills and collects the charges for Bell toll messages sent paid or received collect by its customers, and it performs the inward toll operating on all messages that terminate in its exchanges. In some cases the connecting company operators handle to completion (supervise, time, and ticket) toll messages which originate in their exchanges, while in other cases originating messages are routed either to another connecting company or to a Bell exchange for handling. Exchanges in which all originating toll messages are routed to another office for handling are called full tributary exchanges. In some cases a connecting company operator handles to completion certain originating messages, usually those destined to points to which the originating exchange has direct circuits, while the remaining originating messages are routed to another office for handling to completion. These exchanges are called AB or CLR tributaries. The exchanges at which all originating messages are handled are called toll centers.

Handling Interchanged Messages

THE relationships growing out of the exchange of millions of toll messages between connecting companies and Bell companies cover practically every phase of the business. Only through the closest coöperation is it possible to coördinate the efforts of both groups so that a high grade of telephone service will be provided. This involves not only the provision of adequate plant, as to both grade and quantity, but also the use of such traffic operating methods and routings as will achieve speed and accuracy in the handling of the messages to and from all points encountered in nationwide service. Toll messages may originate anywhere and likewise terminate anywhere, and the prompt and efficient handling of the millions of such messages requires carefully thought-out operating methods and practices.

In order to achieve a universally good telephone service on calls be-

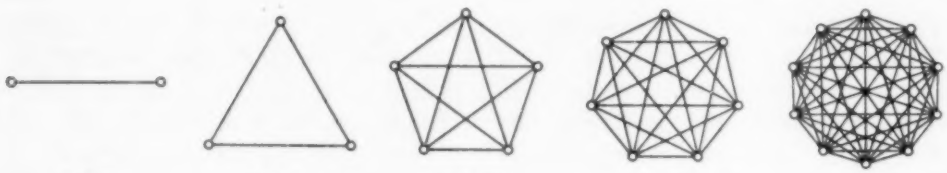

FIG. 3. GROUPS OF TOLL CIRCUITS REQUIRED FOR DIRECT CONNECTIONS BETWEEN VARIOUS NUMBERS OF TOLL CENTERS

tween any two customers, regardless of where they are located or whether they are customers of a Bell company or a connecting company, it is necessary to provide toll circuits in such numbers and so arranged that satisfactory connections may be established quickly. Toll connections may require operators at a number of telephone central offices along the route to connect together toll lines in order to build up the toll circuit between the calling and called customers. These points of connection are referred to as "intermediate switching points" or "switches." Each additional switch introduced in a built-up toll connection increases the time required to establish the connection and reduces somewhat the volume of speech transmitted. The telephone plant must therefore be designed so that the standards of transmission and number of switches required on any call will be such that satisfactory transmission of speech will be provided. The toll calls on which it is most difficult to give a high grade of service are those scattered calls between customers located in remote and widely separated exchanges, because it is difficult to establish such connections and still keep the number of switches to a minimum.

From the standpoint of improved service to the customer, it is desirable, whenever feasible, to provide operating practices that will permit the calling customer to remain at his telephone while the connection is being established. Any improvements in equipment or operating practices that reduce the time of establishing connections or in other ways improve the service to customers are extremely important and are being continually studied.

SINCE 1925 the speed of service of toll calls handled by Bell Companies has been improved from an average of 7.3 minutes to 1.4 minutes at the present time. It has long been recognized that to give an efficient and speedy service requires methods of operating such that an operator anywhere in the country will understand the request of any other operator anywhere else in the country. Obviously, these matters require close coöperation between Bell and connecting companies, and the service today exemplifies such coöperation. The modifications and changes made from time to time in central office equipment, outside plant, and operating practices have permitted the satisfactory handling of toll business which

has grown tremendously over the years. The connecting companies have done their share in contributing ideas as to improvement of both equipment and operating technique.

It was early recognized that to provide an adequate number of direct toll circuits from each toll center to every other toll center in the country was impracticable. For example, to connect two toll centers, only one group of circuits would be required; for direct connections for three toll centers, three groups; for five toll centers, 10 groups; for 10 toll centers, 45 groups; for 100 toll centers, 4950 groups; for 1000 toll centers, nearly one-half million groups of toll circuits, and so on. This is indicated diagrammatically in Figure 3.

Another means of establishing toll connections between toll centers might be to provide direct circuit groups from each toll center to only its nearby toll centers, thus providing a network of circuits between all toll centers in the country. Under such an arrangement, a toll connection between distant toll centers could be built up by switches at each intervening toll center. Such a plan would be most impracticable, however, as it would, in many cases, require too many switches to permit establishing a speedy, efficient and economical service.

The General Toll Switching Plan

A GREAT deal of consideration was given to the broad general problem involved in the routing of calls and provision of adequate circuits, which finally led to the development of the fundamental layout of toll plant and routing of toll messages which today is known as the " General Toll Switching Plan." This plan was developed and adopted by the Bell System just before 1930.

It is of interest to note in passing that the Toll Switching Plan has been carefully studied by telephone engineers of the various European telephone organizations. In 1938 the International Telephone Consultative Committee (C.C.I.F.), at its meeting in Oslo, adopted rules and regulations along fundamentally the same lines for international connections within Europe.

The purpose of the plan is to provide systematically a basic plant layout designed for the highest practicable standards of service consistent with economy, including speed and accuracy.

AN important part of the development of the plan was the determination of proper transmission require-

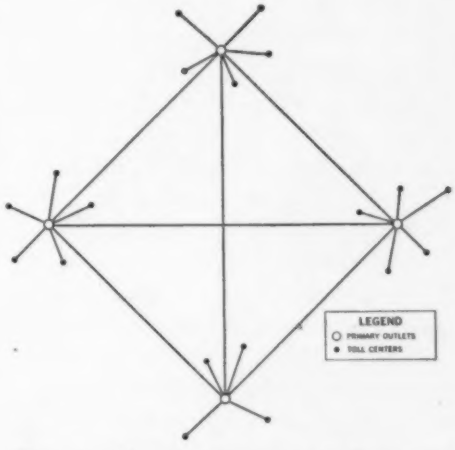

FIG. 4. TOLL CENTERS AND PRIMARY OUTLETS

This diagram shows the operation of the General Toll Switching Plan within a limited area

FIG. 5. THE GENERAL TOLL SWITCHING PLAN

Regional centers and primary outlets in the United States and eastern Canada

ments for each connecting link between offices, such that any toll connection established in accordance with the plan would have satisfactory transmission efficiency. All technical measures of the quality of service, including speed, accuracy and transmission, indicate that the difficulty of giving satisfactory service increases rapidly with the number of intermediate switches. The General Toll Switching Plan, therefore, in addition to establishing standards of design that will provide satisfactory transmission, involves the layout of the toll circuits in such a manner as to reduce to a minimum the number of switches required to connect any two telephones. It is obvious that the provision of such circuits and routing of calls must be considered not only from the standpoint of traffic between any two particular points but also from the standpoint of the best over-all arrangement to provide a flexible and economical nation-wide system. The importance of this is emphasized by the rapid growth in the volume of long-haul traffic.

The general features of the Toll Switching Plan, as applied to a limited area, such as a State, required the selection of a minimum number of exchanges as toll centers. The selection was based on a careful study of the existing and probable future development of toll traffic within the area, and the ability of such exchanges to handle the toll operating work from the standpoint of facilities available, including lay-out of toll line plant and other factors. The selection of such exchanges also required a careful analysis in order to arrive at the best distribution of toll centers to handle the traffic speedily and economically. Within this same area a small number of the more important toll centers were selected as "primary outlets." In general, each toll center in the area is directly connected to at least one of these outlets, and each primary outlet is directly connected to the other primary outlets within the area. This makes it possible, as seen in Figure 4, to connect any two toll centers within that part of the area served by the same primary outlet with a maximum of one switch, and within the entire area with a maximum of two switches.

Choosing the Primary Outlets

THE selection of the primary outlets required not only a study of the particular area involved but also careful consideration of its relation to the nation-wide plan. A minimum number of primary outlets in a given area, capable of handling the traffic, is essential, since the number of circuit groups between the primary outlets increases appreciably as the number of primary outlets is increased. This point will be emphasized by again referring to Figure 3 but now considering each of the toll centers shown there as primary outlets. For example, ten groups of circuits are required to interconnect five primary outlets, and 21 groups are required to interconnect seven primary outlets.

The selection of certain exchanges as toll centers, and certain of these as primary outlets, was made from the standpoint of furnishing the highest practicable standards of service consistent with economy, and without regard to the ownership of the exchange involved. This resulted in the selec-

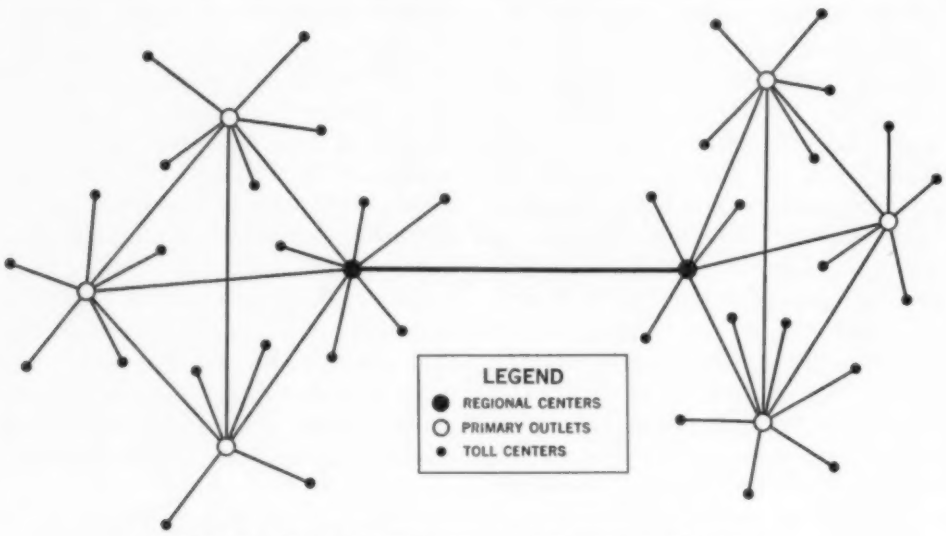

FIG. 6. PRIMARY OUTLETS AND REGIONAL CENTERS

Each primary outlet is directly connected with at least one of the country's eight regional centers

tion of about 2400 toll centers in the United States, of which about 590 are connecting company exchanges, and in the selection of about 140 of the toll centers as primary outlets, of which nine are connecting company exchanges. The distribution of the primary outlets throughout the country is shown in Figure 5.

To facilitate the handling of the longer haul business throughout the country, eight of the primary outlets located in the larger cities have been designated as "regional centers," which are also shown in Figure 5. The method of routing calls between exchanges in different regional areas is illustrated by Figure 6. The plan contemplates that each primary outlet will be connected with at least one regional center and with as many more as is practicable. If the traffic volumes increase sufficiently, then ultimately each regional center may be directly connected to every other regional center in the country. At the present time, through the circuits provided by the plan and other direct circuits, any one of the primary outlets can be connected to another primary outlet served by the same regional center with a maximum of one switch, or can be connected to any other primary outlet in the country with a maximum of two switches.

In addition to the routes provided by the plan for country-wide service, as illustrated in Figure 6, direct circuits or other routings are also provided where the volume of business is sufficient to make it desirable. Figure 7 illustrates such supplementary circuits by dashed lines. The use of such circuits is illustrated in the case of a call from a connecting company customer in Centerview, Missouri, to a telephone in the connecting com-

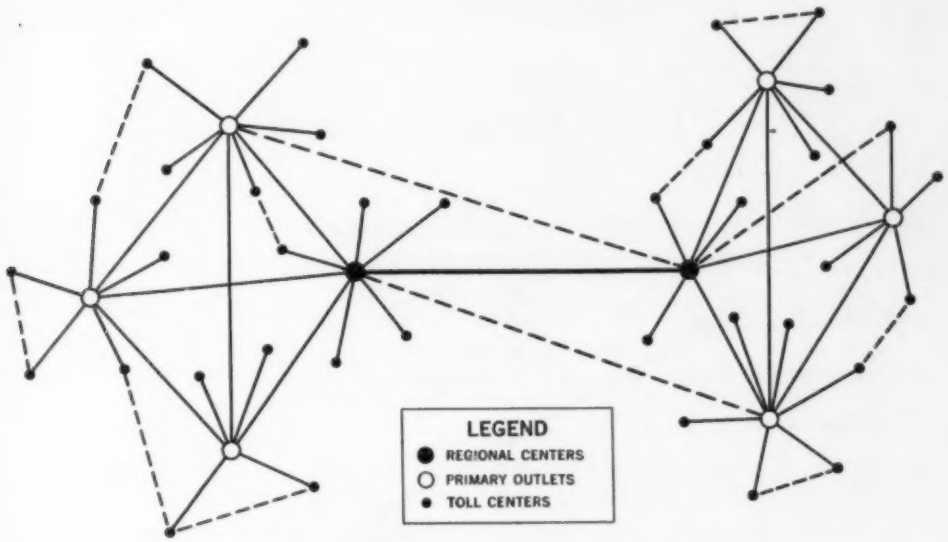

FIG. 7. SUPPLEMENTARY CIRCUITS

In addition to the basic circuits of the General Toll Switching Plan, supplementary circuits (shown by dashed lines) are established when the volume of traffic warrants

pany exchange at Gibsonville, North Carolina, as shown in Figure 8.

The toll circuit groups between regional centers, and in some cases between primary outlets, frequently have a large number of circuits because of the large volumes of traffic involved. More calls per circuit can be operated over a large group of circuits than over a small group. For example, the available conversation time per circuit in a group of ten circuits is almost 22 per cent greater than the available conversation time per circuit in a group of two circuits. This demonstrates why it is frequently more efficient and economical to back-haul the routing of a toll call so that it may be routed via a large group of high grade circuits with good transmission and a fewer number of switches, as is the case shown in Figure 8. All of the circuits between regional centers are furnished by the Bell System. As a result of extensive development work in its Laboratories and through the provision of the highest grade of facilities throughout, it has been possible to reduce the transmission loss to a very low value. This is likewise generally true of the circuits between primary outlets and regional centers.

TOLL calls vary in length, from a few miles to across the continent. The charges for calls also vary, depending not only on distance and length of conversation but also on whether the call is person-to-person or station-to-station and whether week-day rates or night and Sunday rates apply. On calls to and from customers of connecting companies, these companies participate in the furnishing of the service and hence are entitled to a part of the revenue on each such mes-

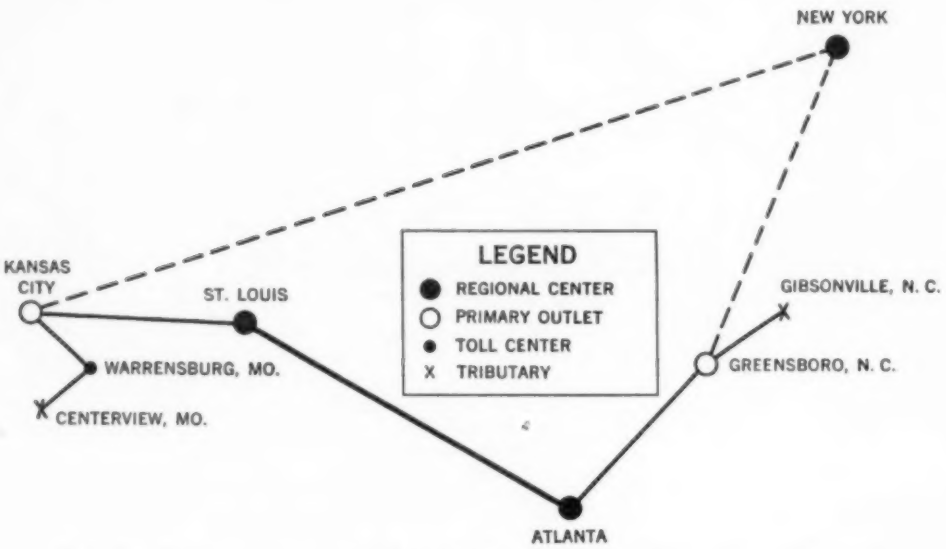

FIG. 8. BACK-HAULING A CALL BETWEEN CENTERVIEW AND GIBSONVILLE

The longer way 'round (dashed lines) is the shorter way home in this instance, requiring only two switches—at Kansas City and New York—between terminating toll centers. In the absence of these high-quality direct circuits between Kansas City-New York and New York-Greensboro, the call would be routed via the regional toll centers (solid lines) and would require switches at Kansas City, St. Louis, and Atlanta

sage. The business relationships arising from the vast interchange of toll messages are described in traffic agreements executed between the connecting company and the Bell company with which it connects. The agreements define the responsibilities and duties of each of the companies, and specify the points of connection of the systems and the toll operating that is to be performed by each. The agreements also provide for the basis of division of revenues derived from the interchanged business.

The fine toll service which is enjoyed today didn't just happen, but is the result of careful planning, together with excellent teamwork on the part of hundreds of thousands of employees engaged in the industry. While the Bell System and the connecting companies throughout the country have for years worked together harmoniously to provide this country with the best telephone service in the world, they are now even more determined in their efforts to meet successfully the important problems that will face the industry during the coming days.

TRENDS IN TOLL CABLE USAGE

Telephone Engineering, Scientific Research, and Manufacturing Skill Are Represented in the Wide and Constantly Growing Toll Cable Network Designed to Insure Service Dependability

By ARTHUR F. ROSE

With national defense and dependability of telephone service the keynote at the present time, the importance of the Bell System toll cable network cannot be overestimated.

As early as 1909, when Washington was substantially isolated by an ice storm during President Taft's inauguration, the management of the Bell System realized the need for a more satisfactory form of long telephone circuit than generally used at that time. A large amount of engineering effort was at once devoted to the solution of the problem, and during the lifetime of many engineers still in Bell System service the character of the plant has changed, from one generally subject to the rebuffs of nature to one that sturdily stands through many of her most savage attacks.

Between these extremes is the story of scientific research, manufacturing skill, and pioneer methods of engineering, combining to foil the telephone's ancient enemy—the ice storm—and also to meet the social and economic needs of a growing nation. The sequence of events leading up to our present toll cable network starts almost with the first conception of the telephone and its possible use in business and social activities.

Only a short time after the invention of the telephone in 1876, it became clear that the interconnection of telephones in individual cities would be the initial step in the development of this new device, but for maximum usefulness it would also be necessary to interconnect the telephones in different cities. The first long distance telephone line was a grounded copper circuit about two miles in length between the Walworth Manufacturing Company in Boston and their works in Cambridge. It consisted of copper wire suspended by glass insulators. Up to about 1900, the early long distance telephone circuits in the United States were practically all of this type of construction, although it had soon been found that for the longer circuits the ground return at first used would not give satisfactory results. By the use of metallic (i.e., two-wire instead of grounded) copper circuits, considerable distances were covered and by 1884 a New York-Boston circuit had been established.

The open wire lines, however, soon

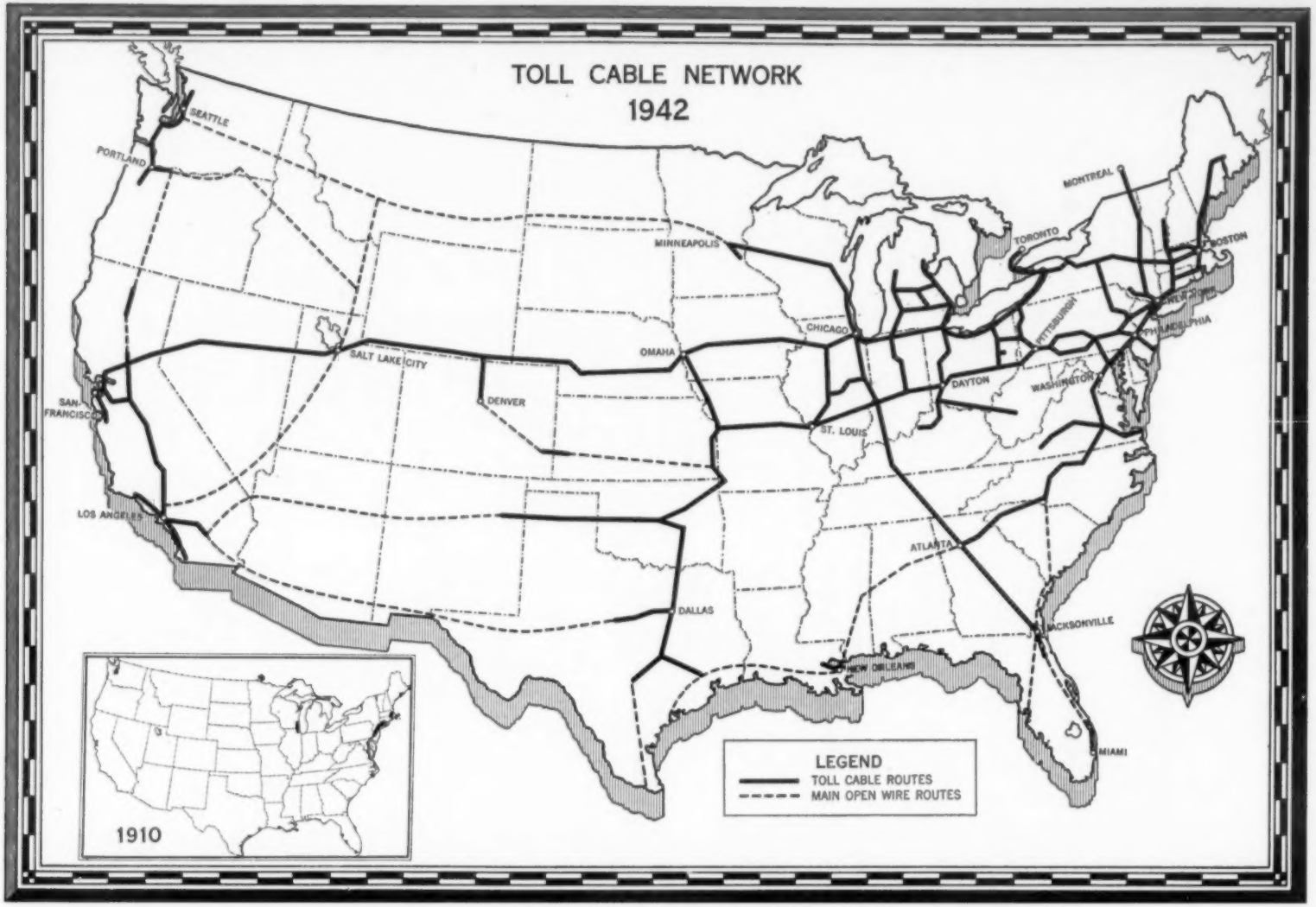

FIG. 1. BELL SYSTEM TOLL LINES—EXISTING AND PLANNED

This is about the way the Bell System's toll network is expected to look on the map by the end of next year. Note the cross-country cable linking the East and the Pacific coast, on sections of which work is now progressing; and contrast the amount of cable shown on the large map with that which existed in 1910 (insert map)

the East and the Pacific coast, on sections of which work is now progressing; and contrast the amount of cable shown on the large map with that which existed in 1910 (insert map)

became inadequate to carry all the toll circuits required and were subject to damage from heavy ice conditions which frequently broke either the wires or the supporting poles and crossarms. Before the turn of the century, the management of the Bell System had come to appreciate the need for improving the reliability of the more important toll circuits between the larger cities, and there was continuous experimentation directed toward finding some way to remove the toll circuits from open-wire type of construction and put them in cable, where a lead sheath protects the circuits from direct action of ice and other hazards. With cable, moreover, it is readily practicable to protect the circuits further by placing them underground whenever this seems desirable and economical. The problem appeared to be almost insurmountable, as the transmission losses were so large that with the types of cables available a few miles of cable transmission was equivalent to 100 miles or more of open wire transmission. For some years after suitable cables had been developed, this higher loss resulted in their being used only in cities, or in very small amounts where they were permitted in the open wire lines under conditions which made such construction imperative. A long toll cable between cities was unheard of.

Extending the Range of Cable

AFTER many discouragements, it was found that under carefully controlled conditions the insertion of inductance at regular intervals along the cable line greatly improved the electrical efficiency of the cable circuits and permitted much longer distances to be spanned with this type of construction. In 1902 a toll cable, the first in the United States to be equipped with these inductances, known as loading, was placed between New York City and Newark, New Jersey, a distance of only about 11 miles, but this historic step was merely the advance guard of a continuing development which gradually but with increasing strength spread across the country. In 1906 cables were placed between New York and New Haven, and New York and Philadelphia; and, spurred on by the critical failure at the time of the Taft inauguration, an underground cable between Boston and Washington, a distance of about 450 miles, was completed by 1913. This cable represented about the practical limit of loaded cable transmission at that time.

The next step in the extension of the application of cables to the toll network required the development of a new tool known as the telephone repeater. The repeater, a device placed at intervals along a telephone line, adds new energy and revives the dying speech currents, sending them along the circuit with renewed vigor. The first crude applications of the telephone repeater were made early in the 20th century on both open wire and cable; but it was not until 1914, when the use of the repeater resulted in a satisfactory transcontinental telephone conversation, that the repeater reached a point in its development where it could be used with assurance as part of plant design.

As soon as it had been proved by the transcontinental experiments that the vacuum tube repeater was satisfactory, it was applied to toll cables and resulted in a rapid expansion of

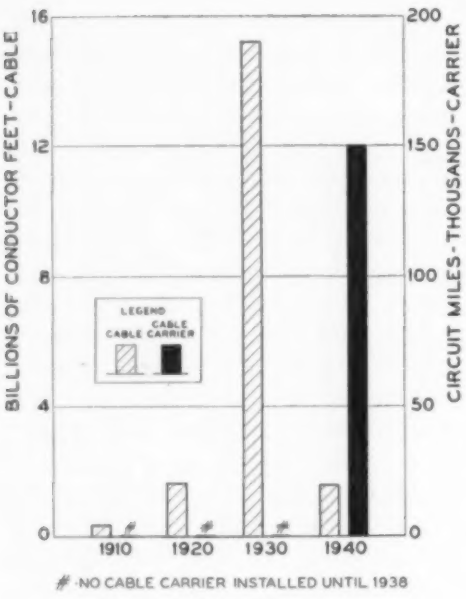

FIG. 2

Production of toll cable, expressed in billions of conductor feet, at four different periods

the toll cable network. The barrier of distance was thus practically removed, and from that time on economic considerations largely controlled the future expansion of the toll cable network. By the end of 1930 the extensions of toll cable covered the entire northeastern quarter of the United States. During the next decade, however, further progress went on at a somewhat slower rate because of the business depression; but at the present time the cable network is again being extended rapidly, with the prospect that by the end of next year the east and west coasts will have been connected by a transcontinental cable. Most of the important cities of the country will then be tied together by toll cables, presenting a tremendous contrast with the picture existing 30 years ago as seen in Figure 1.

The Production of Cable

DURING the years 1929 and 1930, when the toll cable network was previously expanding at its maximum rate, the toll cable manufacturing plants were called upon to produce tremendous quantities of cable for Bell System toll purposes. As the toll cables vary considerably in size, a quantity representing a product of the number of wires in the cable and the length of the cable in feet has been used as an indication of the manufacturing effort involved in producing the cables. Figure 2 shows the production of toll cable expressed in this way for four past periods. It will be noted from this chart that during 1930 the Western Electric toll cable shipments reached the tremendous high of 15 billion conductor feet in that one year. The toll wire mileage included in the cables installed that year would be sufficient to encircle the globe at the equator more than 100 times.

The next point of interest in connection with Figure 2 is the fact that in 1940 the amount of cable manufactured and shipped by the Western Electric Company and installed by the Bell Telephone Companies was only about one-tenth as much as was shipped in 1930. These surprising totals occurred in the face of a rising demand for circuits; toll messages in 1939–1940 increased at a considerably higher rate than in 1929–30 and therefore theoretically a larger increase in cable demand would have been expected, even allowing for differences in plant margins existing in the two periods. But actually only 1/10 of the previous record shipment of 1930 was ordered by the companies in 1940.

The reason for this was the fact that in the meantime an important change had taken place in the type of cable used for toll purposes, springing out of constant effort to develop cheaper and better ways of providing toll circuits.

THE cables which were put in during the very early years of the cable art, such as the first cable between Boston, New York and Washington, employed large gauge conductors, each wire without its insulation being nearly half as thick as an ordinary lead pencil. With the advent of the telephone repeater, there was no need to employ so much copper and it was much cheaper to use a smaller size conductor. Therefore, the wires in the cables used between 1915 and 1930 were largely composed of 19 gauge conductors, about as thick as the fine lead in an ordinary automatic pencil. This was the cable technique which, with a demand for circuits somewhat smaller than in 1940, resulted in the very large quantity of toll cable shown in Chart 2 for 1930.

During the early 30's, when growth was at a low ebb and few cable extensions were being made, the Bell Laboratories continued actively at their development work, and by the end of the period a new step in the cable art had been taken. This new art still utilized the small gauge conductors of the previous decade, but each pair of wires provided 6 times more circuits than previously. This tremendous increase resulted from the application to cable of the carrier technique which had been utilized for many years on open wire circuits. This naturally affected the amount of cable needed by the Bell Telephone Companies, for even although many more circuit miles were theoretically required in 1940 than in 1930, some were supplied by carrier and much fewer conductor miles were actually needed and installed.

Under the older technique, the largest standard toll cables were approximately 2½ inches in diameter, contained about 300 pairs of wires, and produced about 225 voice channels. Under the carrier technique, 300 pairs can be made to yield 1800 voice channels when completely equipped with carrier systems. To do this, however, the 300 pairs must be divided between two cables, one for transmission in one direction and the other for transmission in the reverse direction. Of course, 1800 circuits would hardly ever be required on a single route, and for this reason most of the cables being installed at the present time consist of a pair of much smaller cables, perhaps 40 or 50 pairs each. Two 50 pair cables are large enough, however, to have an ultimate circuit capacity more than twice as great as one of the 300 pair cables of an earlier day.

Repeaters and Other Equipment

IN connection with the difference in the size of the cable, it is to be borne in mind that the multiplication of the number of circuits per pair of wires in the cable is attained by the addition of new and complicated types of carrier equipment. Under the older technique, the cost of equipment and terminations was already an important part of the total cost of the circuits. With the carrier technique, the equipment and terminations are a still larger proportion of the total cost.

FIG. 3. EXTERIOR OF AN AUXILIARY REPEATER STATION

Buildings such as these, normally unattended, are located along the routes of cable carrier-system toll lines

Under the carrier technique, several channels are amplified by each repeater, but the repeaters are needed at more frequent intervals along the line. Under the old voice technique, telephone repeaters were placed at 50 to 100 mile spacing, while under the new technique the higher frequencies used require new energy about every 17 miles.

Figure 3 shows an outside view of a typical auxiliary repeater station of the new art. These small buildings are generally about 20 feet square and house as many as 100 repeaters, amplifying 1200 voice channels. The compact manner in which apparatus is fitted into one of these small repeater stations is very interesting and can be readily seen in Figure 4. No space is provided for permanent operating forces, and the building is designed wholly for telephone repeaters, power supply, and control equipment. The maintenance men who take care of these repeater stations are usually located at about every third repeater point, corresponding to the 50 mile spacing of the old voice technique. Remotely operated alarms tell of trouble if any develops, but otherwise the buildings are not visited except occasionally for routine checks.

Along with the development of the small cable and carrier method described above, there has been a corresponding advance in cable installation methods which will have far reaching effects. Previously, cables were installed either aerially on pole lines or underground in conduit, depending on the expected growth, the former method being used on slow growing routes and the latter being justified when 2 or 3 cables could be foreseen in the next 10–20 years. With the new method of installation, it is economically practicable to place cable underground, and therefore obtain greater security, even although one cable represents the ultimate for the route in question.

Plowing Cables into the Ground

THIS new method involves a single operation of trenching and cable laying, and can be employed on a very large percentage of the toll route mileage involved in our present cable extensions. The engineers of the American Company have developed a plow with a hollow share through which the toll cables are fed directly from the toll cable reels into the furrow cut in the ground as the plow is dragged along by powerful tractors. In the case of the present extension of the transcontinental cable west from Omaha, there are two cables of about 60 pairs each which are being plowed in simultaneously at the rate of several miles a day. Figure 5 shows such a tractor train pulling in cable. In order for this installation, which is to interconnect the east and west coasts by cable, to be completed at the earliest possible moment as a part of our defense activities, plans have been worked out so that the plowing-in can be carried on 24 hours a day, if necessary and weather permitting. This has been accomplished by equipping

the tractor trains with lights to enable them to operate at night almost as easily as in the daytime. It is expected that the transcontinental cable will be completed before the end of 1942, and will result in all cable circuits from New York to San Francisco and Los Angeles, for cables are already available from New York to Omaha and from Sacramento to San Francisco and Los Angeles.

The net result of the rapid expansion of the toll cable network is a great addition to the security of the

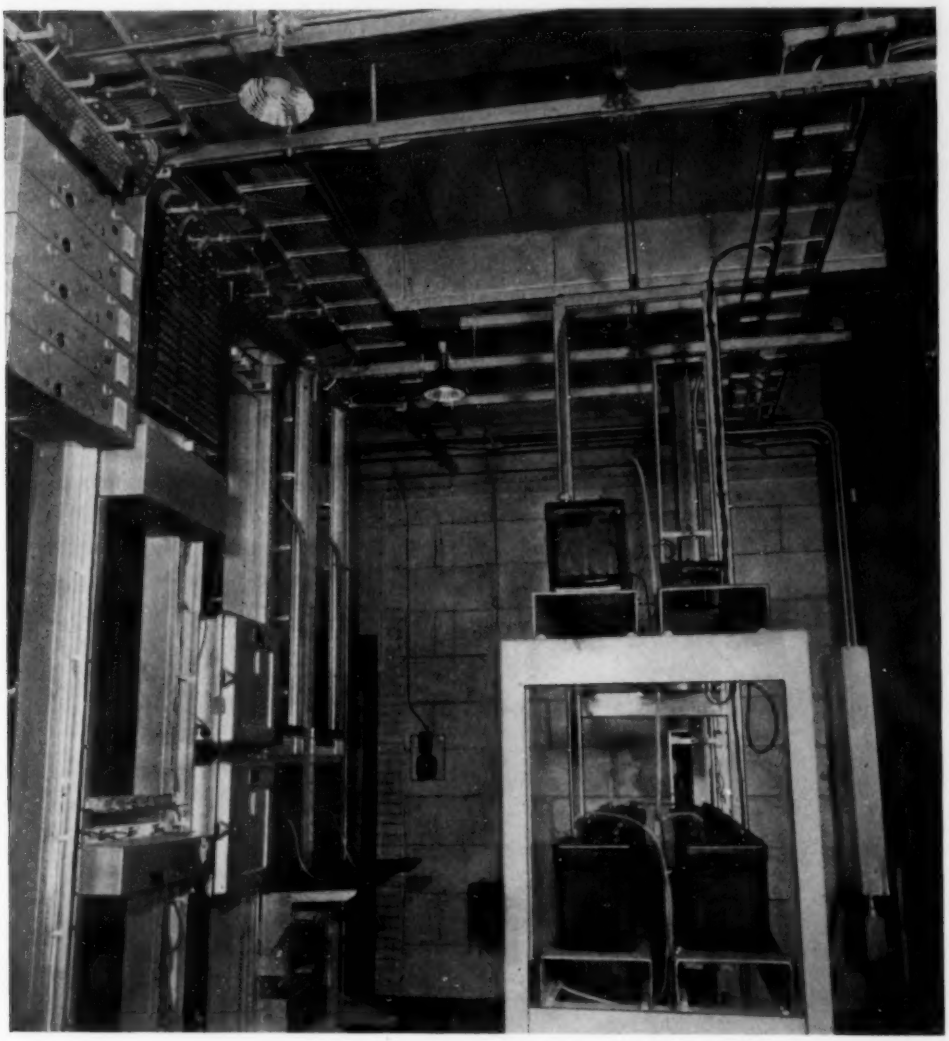

FIG. 4. INTERIOR OF AN AUXILIARY REPEATER STATION

Inside the building shown on the opposite page are compactly arranged the repeaters and associated equipment for amplifying the voice channels transmitted by carrier current

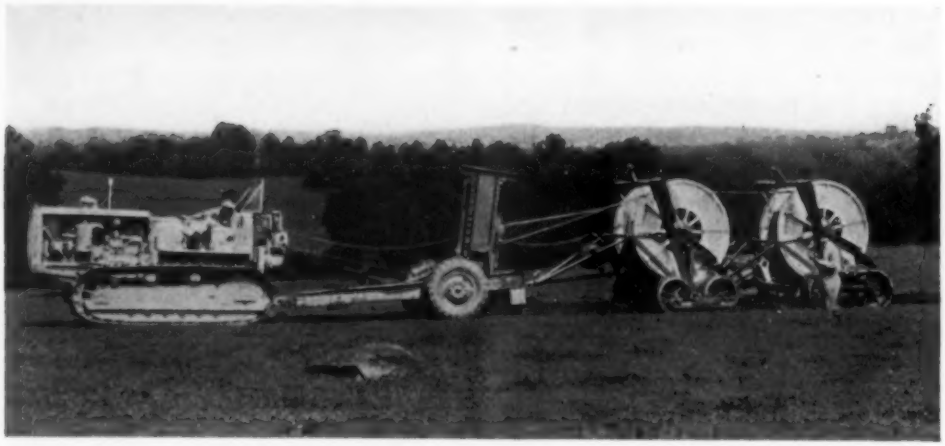

FIG. 5. PLOWING CABLES INTO THE GROUND

Cables from the two reels feed into the furrow through the hollow share of the plow behind the tractor. In heavy going it is not unusual to find two tractors, tandem-fashion, supplying the motive power

toll message plant. The cables, after being plowed in across farm lands, through swamps, below the bottoms of creeks and rivers, are more free from damage and interruption from storms than their predecessors, many of which were on pole lines and, therefore, exposed to many possibilities of damage. Aerial cables, with their lead sheath protection, were much superior to open wire lines, but were still subject to some hazards, such as small boys using them as targets for their small rifles, or traffic accidents along highways.

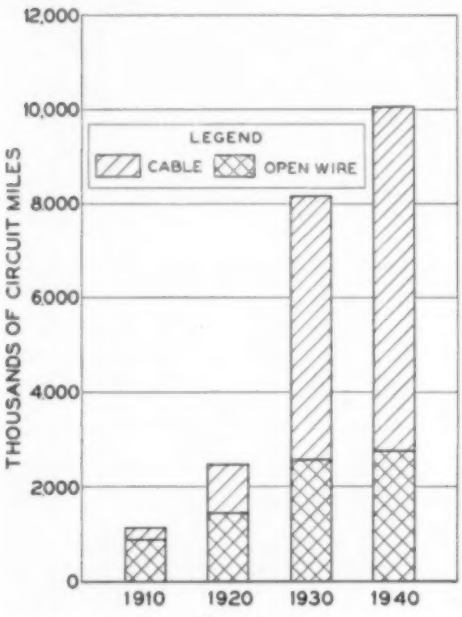

FIG. 6

Relative proportions of toll cable and open wire in the Bell System at four different periods

As more and more circuits are placed in cable, our long distance services become increasingly dependable. It is interesting to note how steady this trend has been and to what extent the toll circuits of the Bell System are now in comparatively storm-proof plant. The accompanying chart (Figure 6) shows how the long distance circuits, practically entirely exposed to the elements in 1910, have now

reached a point where about 75 per cent of the circuit miles used for long distance purposes are in cable.

When one looks at the toll cable map accompanying this article, there still appears to be a large part of the country which is not reached by toll cables. It should be borne in mind, however, that a large portion of the United States is not subject to ice-storm damage and that the older open wire construction is adequate for these parts of the country. Also, through sparsely settled parts of the country, where toll circuit development is low, the open-wire line must necessarily continue to be used because of its lower cost per circuit under such conditions. For these reasons we have not yet attained the ideal of reaching all important towns by means of the cable network, but already substantial progress has been made. By the end of 1942, as a result of a continuing program of cable extension over past years, 82 per cent of our larger cities, those over 50,000 population, will be reached directly by the cable network. Of the remaining percentage not on the cable network, many are in areas not subject to severe storms and therefore comparatively free from service interruptions. The replacement of open wire will continue, of course, and before many more years have passed the prospect is that the other large cities will be connected to the cable network and thus approach closer to the ideal of the Bell System for "a telephone service . . . free . . . from imperfections, errors or delays."

CHEMISTRY BEHIND THE TELEPHONE

The Service of Chemistry to the Telephone Industry Is the Constant Scrutiny and Experimental Reconstitution of the Stuffs That Things Are Made Of

By ROBERT R. WILLIAMS

This is the text of an anniversary radio broadcast made on March 11, 1941, over Station WGY, Schenectady, by the Chemical Director of the Bell Telephone Laboratories.

YESTERDAY was the sixty-fifth anniversary of the first telephone conversation. What the telephone has meant for the comfort of mankind in those intervening years is brought strongly to my mind by an incident of my boyhood. With difficulty I was roused in the small hours of a Kansas morning and told to ride for the doctor while my parents rendered first aid to a desperately sick neighbor. With what heart swellings I set out on the nine mile journey through the night. As, returning, the dawn broke over the hills on the drooping head of my weary horse, the duty had become for me, adventure.

But if, as now, I send my voice out over the telephone on some necessitous midnight errand, the sound waves also have a journey of adventure. Adventure begins just inside the perforated disc into which I speak. For my expelled breath carries not only sound but also moisture which might corrode the delicate moving parts of the transmitter. To prevent this, the most modern instruments are furnished with a thin impregnated silk membrane which detains the moisture but not the sound. Many materials were found to sag in wet weather, and muffled the voice, or they tightened in dry air to give a drum-like reverberation. A new synthetic rubber-like impregnant proved to have the desired properties.

Once through this moisture barrier, the voice must actuate the diaphragm, which is made of a light aluminum alloy and accordingly responds to gentle sounds. Yet it must be rigid, an effect which is produced by precipitation within the metal of an ingredient which is soluble in molten aluminum but which separates as fine particles as the metal cools and is rolled into sheets. The principle is widely used for making alloys which must be both light and strong; for example, aircraft parts.

The diaphragm passes the sound waves on to the transmitter carbon in tiny waves of pressure. The transmitter carbon particles, of the size of sand grains, are hard and shiny to resist abrasion. They also have the somewhat unique property of varying greatly in electrical resistance as they

are compressed by the movements of the diaphragm. An electrical current from a battery flows through the carbon grains as one speaks, in a volume which varies momentarily with the sound wave pressure. This device, the microphone, is therefore in a true sense the heart of the telephone, for it converts sound energy into pulsations of electrical current. If the carbon varied greatly in resistance from day to day or from one instrument to another, it would be impossible to reproduce the sounds of modulated speech; or if the carbon grains wore to a powder, frying noises would be mixed in with the speech. Important means to avoid these evils are the selection of low-ash, hard anthracite as raw material and the adjustment of the roasting process to give a carbon of low hydrogen content.

MY voice, now converted into electrical impulses, travels with a speed approaching that of light but not without incidents on its further journey. It might go astray and be lost in the earth or in the framework of the central office building, if it were not securely directed along its proper path. Outdoors its path is guarded by insulating materials. These may be shielded from atmospheric moisture, as in the case of the paper wrappings around each wire of the cables, which in turn are encased in lead sheaths hermetically sealed from end to end. Inside, there is a highly desiccated atmosphere, which in the case of long cables consists of nitrogen under pressure connected to a signal system which sets off an alarm in case the sheath is perforated.

Part of my voice's path may lie underground, where the sheath is subject to corrosion from stray earth currents. Part of it may be supported by poles, on strands of steel. The poles are subject to the attack of wood-rotting organisms of the mushroom family and must be protected by toxic substances, such as creosote, within the cells. Part of the path is usually over wires which are insulated with rubber and exposed to sun and sleet and to tossing tree branches. The rubber must be tough or it will cut through at the insulators under sleet load; it must be protected from the sun by weatherproof braid or it will soon lose its pliability and strength.

WHERE my electrical voice passes through central offices to be connected to the proper party among the many I might call, textile insulations are much used to aid flexible and compact arrangements. There is ample chance for the voice currents to leak away through the internal moisture of the fibres unless the textiles are highly purified of traces of conducting salts. Tarnish films may form at any one of thousands of electrical contacts and my voice may balk at the gap caused by a faint film or be distorted by invisible arcs sputtering through it. All these insulations and conducting or contact materials are safeguarded by chemists who study their initial compositions and the degradations they may undergo from electrolysis or corrosion from dust or atmospheric moisture or impurities. All along its route the channels which carry the electrical counterpart of my voice are subject to slow deteriorative processes which may be likened to the hard-

ening of our arteries as age creeps through our bodies. Much of what the chemist is called upon to do in the telephone industry is to anticipate and to retard their progress.

If my voice has far to go, its feeble currents will be greatly weakened in their travels by dissipation in the line. This effect is reduced by passing these currents through copper coils wound 'round a magnetic core. The action of these loading coils may be likened to a step-up transformer at the terminals of a power line. To be most effective, the core must be very permeable to magnetic lines of force but highly resistant to induced electrical currents. The results are best produced by alloys of iron and nickel so brittle that they can be ground to a fine powder. Each particle is then insulated from its neighbors and the powder pressed into the desired shape to form the core.

If the distance is still greater, my voice must be rejuvenated periodically by passing through an amplifier. This could be done by interposing a receiver and transmitter in the line and, so to speak, make the telephone shout into its own ear. Nowadays, however, it is done by imposing the voice current on a grid past which is flowing a stream of electrons from a hot filament to a plate. When the pulses of the voice current reach their peaks, the grid is positively charged and catches many electrons to reinforce the pulse; as the voice pulses approach their valleys, the grid is negatively charged and repels the electrons. So the voice currents are re-accentuated and go on their way. Their revitalization is essentially due to the reservoir of free electrons which the filament provides. The electrons emanate from a coating on the filament composed of barium and strontium oxides. Its structure and composition give it the quality of a spring-board from which the otherwise bound electrons may leap off into space.

ARRIVED at the station called, the electrical record of my voice must be retranslated into speech. This is done by passing the voice currents through a coil which lies between a diaphragm of magnetic material and a strong but small permanent magnet. As the voice pulses rise in the coil, they add to the field strength of the permanent magnet and draw the diaphragm toward the magnet; as the pulses fall, they subtract from the magnet's field strength and allow the diaphragm to fall away. The movements of the receiver diaphragm so faithfully reproduce the movements of the transmitter diaphragm against which I spoke that you not only understand my message but you recognize my voice. The nicety of reproduction is greatly aided by nicety of composition, both of the magnet and the diaphragm. Their compositions are different, but each is preponderantly iron plus cobalt. The addition of vanadium in the diaphragm facilitates its manufacture without impairing its sensitivity to the weak voice pulses; the inclusion of molybdenum in the magnet provides a permanent and compact source of magnetic force.

So chemistry serves the telephone as it serves medicine, manufacturing and other callings, by constant scrutiny and experimental reconstitution of the stuffs that things are made of.

FOR THE RECORD

OUR PART IN THE NATION'S DEFENSE PROGRAM: A STATEMENT BY PRESIDENT GIFFORD AT THE ANNUAL MEETING OF STOCKHOLDERS ON APRIL 16

WE of the Bell System are concentrating on doing well our part in our country's defense program, which in size and speed is undoubtedly the biggest job ever undertaken by any country. It is not easy, in a few words, to portray to you the magnitude of our task and the diversity of the problems we must face and solve in carrying out our part in that defense program. Perhaps it will help if I try to illustrate by specific instances.

Last September we learned that Camp Edwards, up on Cape Cod, was to have a quota of upwards of 25,000 men. The camp is located between two small towns, and it was up to us to figure out how to furnish adequate service for this big military establishment. We weighed all the possibilities, and the upshot was the decision to build an entirely new central office at Cataumet, not far from the camp. On October 4 the New England Telephone and Telegraph Company broke ground for a brick building of colonial design, to house an initial installation of 30 switchboard operators' positions. Installation started on November 4, and by January 4 the operating force had been trained and everything was in readiness for service —three months to the day after ground was broken. The sequel to this is that already 15 more switchboard positions have been ordered, increasing the capacity of the central office by half, and there is room for still another 15 positions if they are needed.

Another example of the speed with which we can move, and also of the fine spirit of our people, occurred when we were asked to furnish telephone service ahead of schedule for a big ordnance plant which was being constructed not far from St. Louis, Missouri. Crews of the Southwestern Bell Telephone Company got on the job at daybreak on last Thanksgiving morning, ate their Thanksgiving dinners beside the road, and in three days, working from daylight to dark, put in five miles of plowed-in cable and open wire along a heavily traveled highway.

ON Sunday, January 26, fire gutted the Administration Building at the Norfolk Naval Base, in the territory of The Chesapeake and Potomac Telephone Company of Virginia, completely interrupting all communication service through the headquarters of the Fifth Naval District. The facilities destroyed included the private branch switchboard, power plant, interior cables and cable records. The alarm was given at 9:30 A.M. By 11 A.M.—and remember that this was a Sunday—about 40 telephone installers, splicers, linemen, engineers and staff men were at the scene with trucks, tools and equipment. Half an hour later, telephone service had been

provided over temporary facilities to the offices of the Commandant of the Fifth Naval District and his aides. Two small sections of private branch switchboard had also been obtained locally, and temporary service for other vital telephones at the Base was being given by Sunday afternoon.

By Sunday noon a preliminary survey had been completed, and the local people had Western Electric's Kearny Works on the wire. By ten o'clock that night a complete new 10-position private branch switchboard, weighing five tons, was ready to go. It was packed in a special car which was attached to a passenger express train, and reached Norfolk at 10:30 Monday morning. Western's Hawthorne Works, in Chicago, and its Washington distributing house also shipped a considerable amount of miscellaneous relay equipment and cable for the restoration. When the new equipment arrived on Monday, Chesapeake and Potomac plant men and Western Electric installers were on hand to install it quickly. The Navy cooperated splendidly, our men worked day and night, and service was being given through the new switchboard just 69 hours after the alarm of fire had been given.

THOSE are interesting examples, I think, of what we can and sometimes have to do. I could cite many other illustrations of unusual activities of this kind going on here and there in the Bell System. Even under normal conditions every effort is made to work out and adhere to schedules of construction and installation to meet the requirements laid down by the defense agencies. In order to coöperate quickly and fully with the various government departments, the American Telephone and Telegraph Company has maintained an office in Washington for some years. As soon as the decision has been made to build or enlarge a military or naval establishment or a defense plant, word reaches our representatives there, and is quickly passed on to the operating company in whose territory the project is to take shape; to the Western Electric distributing house serving that company and to Western's headquarters; and to the A. T. & T. staff in New York. The operating company begins at once to survey the kind and amount of work it will have to do and the plant which will be needed, and Western Electric schedules tentatively the probable order for the private branch switchboard, distribution cable, and other items which the project will require. Our staff people here are always available, and are frequently consulted about various aspects of such an undertaking.

As each project becomes more definite, plans for manufacture and construction can proceed with assurance. By the time the order has actually been signed, much preliminary work has been accomplished. We have been quite successful so far in meeting scheduled dates for service to defense projects. Of course, in many cases our Operating Companies and Western Electric have had to work under pressure to do it.

NEW or enlarged Army and Navy camps, bases, aviation fields, and other military establishments, together with Government-owned or financed plants making ordnance, aircraft and other war products where major telephone construction is involved, total about 600. This includes establishments planned, under construction, and completed. We have finished substantial telephone installations at about 200 of these places, and the facilities at the remaining places will be ready when needed. I want to use just one figure to illustrate the size of our job at these 600 establishments: the cables which we have already installed or expect to install in giving service to them will contain a total of more than a million and a quarter miles of wire—and that is enough to wrap around the earth 50 times.

Our part in the nation's defense activi-

ties is not by any means confined to the service we have already provided or will provide to these 600 Government establishments. Many thousands of privately-owned industries are making military materials of all sorts, totalling billions of dollars, under direct contracts with the Government. The great activity in all of these military and manufacturing establishments is reflected today throughout the whole industrial and social structure of the country, and is to a great degree the cause of the heavy demands generally for telephone service and equipment. In reality, therefore, a very large part of all our current telephone plant expansion is directly associated with the nation's defense activity and is vital to it.

In addition to manufacturing all the equipment and materials needed by our Operating Companies for this huge construction job, Western Electric is furnishing directly to the Army, Navy, the air services and the Coast Guard, quantities of switchboards, cable, telephones, microphones, radio telephones, field sets, field wire, and other items of communication equipment. Moreover, Western's Specialty Products Division has already received Government orders for highly specialized communication equipment totalling approximately $40,000,000.

These figures are a few days old, and are therefore not complete, for even days make a difference now.

Obviously, where camps, aviation fields, ordnance plants, etc. are located in territories served by independent telephone companies, it is ordinarily they and not we who provide the service and equipment. I should like to emphasize the point made in the Annual Report that the splendid cooperation between these 6400 independent connecting telephone companies and the Bell System is extremely important in marshalling the resources of the entire telephone industry in the interest of national defense.

We have had for some time a group, including representatives of the Bell Telephone Laboratories, Western Electric, and our headquarters' staff, at work on substitutes for such critical materials as aluminum, nickel, zinc, and magnesium, all of which are used in telephone apparatus. We have pledged to the Priorities Division of the Office of Production Management in Washington that we will make every effort to reduce our use of such materials, even at some penalty in cost and effectiveness. It is not a simple matter, but we have already made some real progress and we hope to go further.

More than 200 of the Laboratories' scientists and engineers are engaged in research and development projects for the Army and Navy and for the National Defense Research Committee. Some 60 of the Laboratories' staff are employed in telephone problems which have been directly occasioned by the national defense situation, and another 80 are engaged in fundamental research for which the methods and point of view have been changed because of problems suggested by defense activities.

The Selective Service Act has taken about 700 of our men so far, and about 1,500 who were members of the National Guard and the Army, Navy, and Marine Reserves are now on active duty. Despite these absences on leave, the number of employees in the System, including the Western Electric Company and the Bell Telephone Laboratories, has increased 18,000 since the first of the year and is now about 340,000.

The President of your Company is Chairman of the Industry Advisory Committee of the Defense Communications Board, and ten other members of our headquarters organization are assisting in the work of this Board as members or alternate members of its several committees. Dr. Jewett, a Vice President of this Company and Chairman of the Board

of the Bell Telephone Laboratories, is serving as a member of the National Defense Research Committee, and more than a score of the leading scientists and executives at the Laboratories are serving as members or as consultants in the work of its various divisions and sections. Mr. Harrison, A. T. & T. Vice President and Chief Engineer, who has been on leave of absence since last summer on government defense work, has recently been made Chief of the Branch responsible for shipbuilding, construction, and supplies in the Office of Production Management, and a dozen other men from the Bell System have been loaned to the government in connection with the defense program.

WORK is going ahead with sections of the new transcontinental telephone cable mentioned in the Annual Report. This cable is being laid underground, starting west from Omaha, where it connects with the eastern cable network. In the meantime, additional equipment is being added to our open-wire lines west of Laramie, Wyoming, which, in conjunction with this cable, will provide another 36 circuits to the Pacific before the end of this year. New wire is also being strung between Oklahoma City and Albuquerque, New Mexico, which, with existing wires over the remainder of the distance and with associated equipment, will provide 32 more circuits to the Coast within the next few weeks. Thus we shall have this year 68 more transcontinental circuits—an increase of about one-third over the already existing 200 circuits. These east-west lines, running in four widely separated main routes across the continent, are, of course, interconnected at a number of points.

While we are working at high pressure to give telephone service to the Army and Navy, and to provide other equipment for the two services, almost every other industry in the United States is also working on defense production, as I said a minute ago. We have our part in that because as others increase the tempo of their efforts they inevitably use the telephone more and use more telephones, for the telephone is an instrument of speed and accuracy in modern affairs. And this means that we have a little part in almost every effort toward national defense. A little part in every effort adds up to pretty large figures.

We have never yet had a net gain of as much as a million telephones in a year —last year's gain of 950,000 was the highest we ever had—but if the present rate of growth should continue throughout the year, we would gain nearly a million and a half telephones—50 per cent more than ever before in one year. In any case, an increase of well over a million looks certain. Long distance calls are running about 25 per cent above a year ago—some days more than 35 per cent. That is a percentage increase in one year which we would normally expect might take place over a period of two or three years. Actually, we are now handling, on the average, more long distance calls every day than we did during the unprecedented peak of traffic which we experienced in September of 1939, when the war broke out in Europe. All of this necessitates additional facilities, and we now expect to spend in 1941 about $400,000,000 for new construction—$110,000,000 more than we spent last year . . .

THE speed and vastness of our country's defense program and the importance of the telephone to its success are a challenge to every man and woman in the Bell System, and I am sure that you, as stockholders, would be proud if you could see the spirit and competence with which the entire personnel is meeting that challenge.

DR. CAMPBELL RECEIVES THE EDISON MEDAL

THE Edison Medal for 1940 has been awarded by the American Institute of Electrical Engineers to George Ashley Campbell, who retired from the Bell Telephone Laboratories in 1935 after thirty-eight years of Bell Telephone service. The award is "in recognition of his distinction as a scientist and inventor and for his outstanding original contributions to the theory and application of electric circuits and apparatus." Among the eminent engineers and scientists who have been recipients of the medal are Elihu Thomson, George Westinghouse, Alexander Graham Bell, John J. Carty, Michael I. Pupin, Robert A. Millikan, Frank B. Jewett, and Bancroft Gherardi.

In accepting the medal, at the winter convention of the Institute, Mr. Campbell said in part:

"Curiosity is as good an explanation of the Edison Medal award as I could find . . .

"In the Bell System I have found the greatest opportunity for the pursuit of curiosity. It was a fascinating field 40 years ago, and during that interval its expansion has been phenomenal, both quantitatively and qualitatively. What was even more important in my own case was that I became a part of a research and development organization with clear-cut goals, high standards of performance, recognition of the importance of the division of labor, and the advantage of teamwork.

"In the Bell Organization, I was assigned assistants who could do many things with greater dispatch and efficiency and perfection than I could. To some of these assistants I later reported myself, and others have carried on the work into difficulties which I myself could never have surmounted.

"You will see that it is perfectly natural that I am an admirer of that kind of teamwork which represents a division of labor in the intellectual field. At one and the same time it gives a greater opportunity to those whose talents lie within rather narrow fields, and it results in an integrated product greater than the sum of the individual efforts. For reasons I have just explained, I feel that I am the beneficiary of the group method of attacking scientific problems. Without the collaboration of innumerable associates in the Bell System, the contributions you have designated to be mine I probably should not have succeeded in making. It is a distinct pleasure to me to recall these many associations and to testify that those who have been my colleagues over the years are in large part responsible for the honor of receiving the 1940 Edison Medal."

CONTRIBUTORS TO THIS ISSUE

GRADUATED from Drury College in 1911 with the degree of B.S. and from the University of Pennsylvania in 1914 with the degree of B.S. in E.E., FRED K. ROWE joined the Engineering Department of the A. T. & T. Company in the latter year. After completing the student training course, he was assigned to work on central office and P.B.X. power equipment matters. He was later engaged on manual central office equipment problems, and at present is in charge of the group handling local manual and auxiliary equipment and central office and P.B.X. power plants.

AFTER studies at Princeton and at New College, Oxford University, FRANK P. TOWNSEND, JR., entered newspaper work as a reporter on the Newark, N. J., *Evening News*. In 1926 and 1927 he was successively city editor and managing editor of the Hollywood, Fla., *News*. After a brief period of free-lance advertising and publicity work, he joined the Publicity Department of the New Jersey Bell Telephone Company in 1928. To prepare his article, he interviewed Professor Reager and members of his classes.

BORN and educated in England, H. M. POPE gained his first experience in the telephone business with The National Telephone Company, then operating in Great Britain. From 1906 to 1909 he was Engineer in charge of outside plant construction in South Wales. Coming to the United States in 1909, he entered the employ of the New York Telephone Company Plant Engineering Department in New Jersey, where he remained until the war. Early in 1917 he joined the Signal Corps, U. S. Army, and later was in charge of the Signal Corps engineering department for the Eastern Department. Returning to the New York Telephone Company in 1919, he soon was transferred to the Commercial Engineering Department of that company in New York City. In 1921 he became an engineer in the Department of Operation and Engineering of the A. T. & T. Co., and since 1933 has been its General Commercial Problems Engineer.

AFTER graduating from Colorado College with the degree of B.S. in E.E. in 1914, ARTHUR F. ROSE joined the General Engineering Department of the American Telephone and Telegraph Company. Upon completing the student training course for new employees, he was assigned to the development work then under way on the New York-San Francisco route which culminated in the first transcontinental telephone service in 1915. As a result of this initial acquaintance with telephone repeaters, he continued in transmission work dealing particularly with these devices. In 1919, when the General Engineering Department was divided and the O. and E. Department formed, Mr. Rose was assigned to the group which was concerned primarily with the application of repeaters and carrier systems in toll engineering. In 1939 he was transferred to the plant extension section, where he has continued to the present time. He has contributed several articles to the *Bell System Technical Journal* and the BELL TELEPHONE QUARTERLY, all of them dealing with various aspects of the toll plant.

AFTER receiving the M.S. degree at the University of Chicago in 1908, ROBERT R. WILLIAMS spent eleven years as a chemist in the service of the Philippine Government in Manila and the Federal Government in Washington. He joined the Engineering Department of the Western Electric Company in New York in 1919, where he conducted studies of submarine cable insulation and later of textile insulations for central offices. Paragutta, on the one hand, and purified textiles, on the other, as now extensively used in the Bell System, are outgrowths of the studies inaugurated by him. When the Bell Telephone Laboratories were organized in 1925, he became Chemical Director and has since had general charge of chemical and metallurgical investigations of the manifold materials used in telephone engineering practice. His avocational activity has brought him distinction in another field. Becoming interested in the chemistry of nutritional disease through his contact with beri-beri in the Philippines, he has continued this study throughout his professional career by alliance with various research organizations and with the aid of funds from foundations, notably the Carnegie Corporation. Working at Columbia University and utilizing the time freed by the short working weeks of the depression period, he brought to a successful conclusion, with the aid of a small group of affiliated workers, the isolation, determination of structure, and artificial synthesis of vitamin B_1. The availability of this substance has rendered possible the present program of enrichment of flour and bread under the auspices of the Federal Government and the National Research Council. He has been honored with medals of the American Chemical Society, the Franklin Institute, and the American Association of Manufacturers, and by honorary degrees of D.Sc. from Ottawa and Ohio Wesleyan Universities.